MEASUREMENT OF INTERACTION CROSS SECTION OF COSMIC RAY Fe NUCLEI (E>4 GEV/N) WITH Al TARGET

G.X. Ren, Y.Z. Zhou, R.Q. Huang, M.Y. Chen
Institute of High Energy Physics
Academia Sinica
Beijing China

1. Introduction

Although the study of relativistic heavy ion interaction encumbered by the low intensities of the incident heavy nuclei in cosmic ray experiments, however, one can use a suitable structure of detector to attain a result with a reasonable accuracy.

In this paper we present a cross section value of Fe(E> 4 GeV/N) with Al. We use CR-39 as detector and Al as target. The cross section value is estimated using maximum likelihood method.

2. Detector

The detector which consists of a stack of CR-39 sheets sanwiched by Al plates is designed for measuring Fe-Al interaction cross section, the Al serving as target and CR-39 serving as detector. The thicknesses of a CR-39 sheet and an Al plate are 1.6 mm and 1.8 cm, respectively. There are 6 layers altogether.

3. Experiment procedure

The detector was launched by a balloon near Beijing in 1982 to a ceiling height of 37 km and lasted for 10 h. The effective cutoff rigidity is 9.4 GV, the recorded threshold for Fe E>4 GeV/N, a value slightly higher than the one reached by heavy ion accelerator so far.

The CR-39 sheets were etched in 6.8 normal NaOH solution with temperature of 70°c for 40 h. The reduced etch rate of CR-39, V_T/V_B-1, and dip angle of impinge particle are obtained from the measurement of the major and minor axes of etch pit ellipses.

Among the recorded nuclei with charge $Z \geqslant 10$, 322 tracks are identified as Fe nuclei with resolution of 0.6 e.

According to the position and dip angle of impinge particle in a sheet of CR-39 and the thickness of target plate, one can calculate the expected position of the particle in the next sheet of CR-39 below target easily. If an etch pit at the expected position possesses a major and minor axes within the error 1.5 μm with the impinge particle at former sheet, namely possesses a charge within the error 1 e and a dip angle within 2° with the impinge one, then this particle is thought to pass through the target without interaction, otherwise a nucleus-nucleus interaction is assumed.

Every Fe track is followed downwards until an interaction takes place or it goes out the detector. 205 interactions satisfying this criterion mentioned above are observed and the total track length been followed $\sum_{i=1}^{N_0} L_i$ = 1854.3 cm (N_0=322, the number of incident particles)
A maximum likelihood estimation of Fe-Al collision mean free path gives

$$\lambda = \sum_{1}^{N_0} L_i / N \qquad (1)$$

where N is the number of interactions.

The variance of λ is

$$\mathrm{Var}\ (\lambda) = \lambda^2 / N \qquad (2)$$

4. Result and discussion

According to eqs (1) and (2), the maximum likelihood estimation of Fe-Al collision mean free path is obtained as $\lambda = 9.04 \pm 0.63$ cm which corresponds to the cross section value $\sigma_{Fe-Al} = 1.83 \pm 0.13$ bar.

In our analysis the interaction point is assumed in the middle of plate when an interaction takes place inside it. The error of λ caused by the uncertainty of interaction points is estimated by

$$\Delta\lambda \cong H\sqrt{N_0}/N\sqrt{12} \qquad (3)$$

where H is the thickness of target plate.

In order to increase the measuring accuracy of λ, larger number of interactions is needed. It means H should be increased. However, increase of H is limited by the relation $\Delta\lambda < [\mathrm{Var}(\lambda)]^{1/2}$. In our case, $\Delta\lambda = 0.04$ cm is still much less than the statistical error. Even if the number of incident particles is not so large, we can obtain a comparable result with work performed on accelerator.

References

Li Tipei, " Treatment in experiments ", Science Press, Beijing, 1980.

F. Fumuro, R. Ihara, 16th ICRC., 6 (1979), 166.